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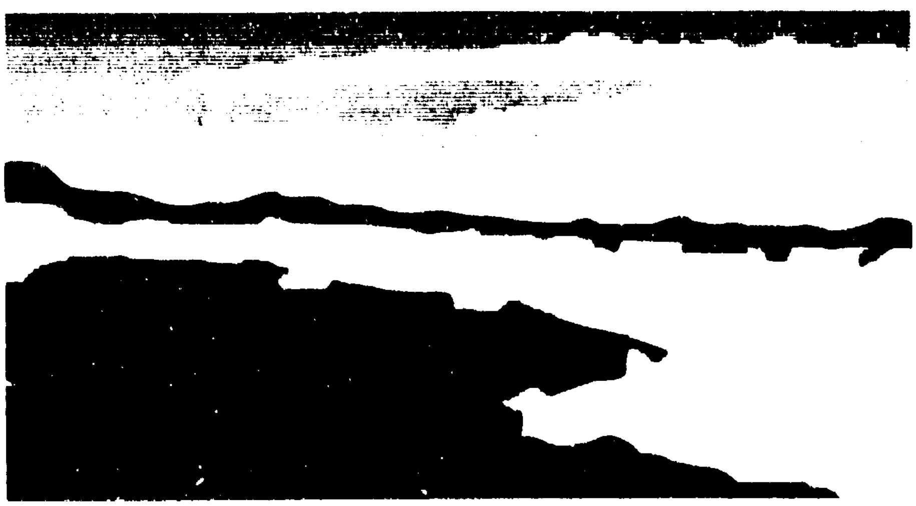

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Fluid Dynamical Predictions for Au+Au Collisions at AGS

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Signatures of collective effects are studied in the Quark Gluon String Model and in the Fluid Dynamical Model for Au+Au collisions at 11.6 A GeV. In the fluid dynamical model the dependence of measurables on the QGP formation in the EOS is pointed out, although the max. total amount of pure QGP formed is only 4 fm^3 in these reactions. In QGSM the lifetime and extent of latent energy in strings is studied.

In most reaction models of relativistic heavy ion collisions where a first order phase transition to the QDP is considered, it is assumed that the phase transition is rapid compared to the dynamics of compression or expansion, and consequently instantaneous phase equilibrium is assumed to be present. This assumption leads to a mixed phase according to the Maxwell construction, which decreases the pressure in a large domain of the phase space, even if only a small amount of QGP is present. Thus some consequences of the QGP in the EOS are already apparent before a large quantity of QGP is present. Recent studies [1, 2] indicate that explicit calculation of phase transition dynamics yields a dynamical hadronization not far from the Maxwell scenario.

In string models QGP formation is not considered explicitly, but intermediate non-hadronic objects, strings are formed. These absorb an essential part of energy and baryon charge during the initial stages of the reaction. As pointed out earlier [3], the string density may become very large, so that string-string interactions in principle should not be neglected. Comparison of string model predictions with experiments indicate that an accurate description of massive strange baryons is possible only if string-string fusion, string-rope formation, or di-string formation are considered. The formation of such larger non-hadronic objects is necessary to provide sufficient energy for massive baryon formation. The dense soup of interacting and partly fused strings can be considered as a non-equilibrated precursor of the Quark Gluon Plasma. The actual EOS of such string models has not been eva'uated so far.

Let us first demonstrate the flow patterns in central reactions in the fluid dynamical model with two equations of state, one with pure hadronic matter and the other including a strong first order phase transition to QGP [3]. If a QGP is present in the EOS the fluid dynamical model predicts the formation of 4 fm^3 of pure QGP. This can be compared to 50 fm^3 in Pb+Pb reactions at 160 A GeV. Thus the amount of QGP is not sufficient to provide any direct QCD signal like J/Ψ suppression, or in di lepton emission. However, as we will see the secondary changes due to the softness of the EOS are still detectable.

The average baryon density increases to 10 (7) n_0 during a central Au+Au collision with a QGP (Hadronic) EOS, and the break up time is around 9.11 (7.8) fm/c respectively. *I.e.*, the phase transition leads to an increase of the collision time by about 30-40%!

The baryon rapidity distributions indicate strong stopping for both EOSs, but their dependence on the break-up time and on the EOS is about the same. Thus, the baryon rapidity distribution is not an obvious signal for the phase transition. The average transverse momentum for baryons, $< p_t/A >$, is about 1 GeV/c at all rapidities. It does not depend strongly on the EOS. The pion rapidity distribution is even less of a phase transition signal, because in the fluid dynamical model we consider thermal pions at their break-up only. This is because of the extremely strong temperature dependence of the thermal pion spectra.

In the QGSM the rapidity distributions of protons and negatives indicate similarly strong stopping. The spectra are even more peaked that in the fluid dynamical model.

It should not surprise us that the collective fluid dynamical effects are exhibited much more clearly at finite impact parameters. We have studied Au+Au reactions at b=5 fm. The average density increase is smaller now due to the spectators: 5.5 (4) n_0 for QGP (Hadronic) EOS, see Fig. 1. The amount of pure QGP formed is negligible (1 fm^3).

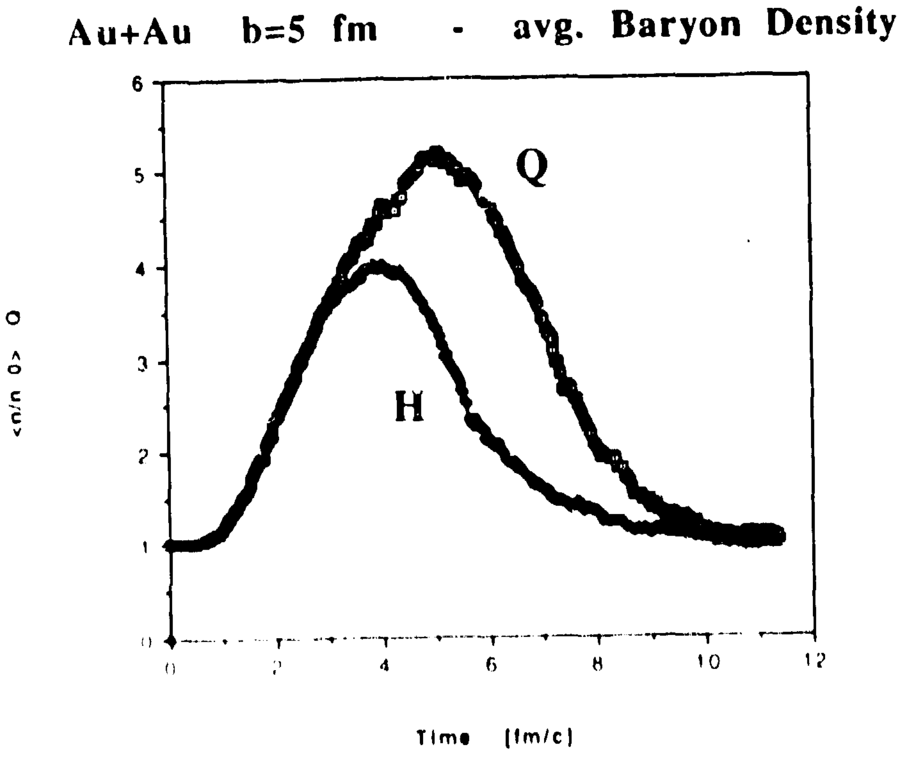

Figure 1: Average baryon density increase, $< n/n_0 >$, versus time in an Au+Au collision at 11.6 A GeV and b=5fm, for QGP (Q) and Hadronic (H) EOS.

We can characterize the collective flow in the x – z (reaction plane), y and z (beam) direction by $T_{ij} = \sum p_i p_j$. The longitudinal flow initially decreases strongly; at the maximum compression it reaches about 10% of the initial value.

then it raises back to about 30-40% depending on the EOS. In the reaction plane the flow F_x is about 25% larger for the hadronic EOS at its maximum.

The strongest and clearly observable effect is in the Squeeze-out (y-) direction where the flow, F_y is twice as large for the hadronic EOS than for QGP EOS! (Fig. 2).

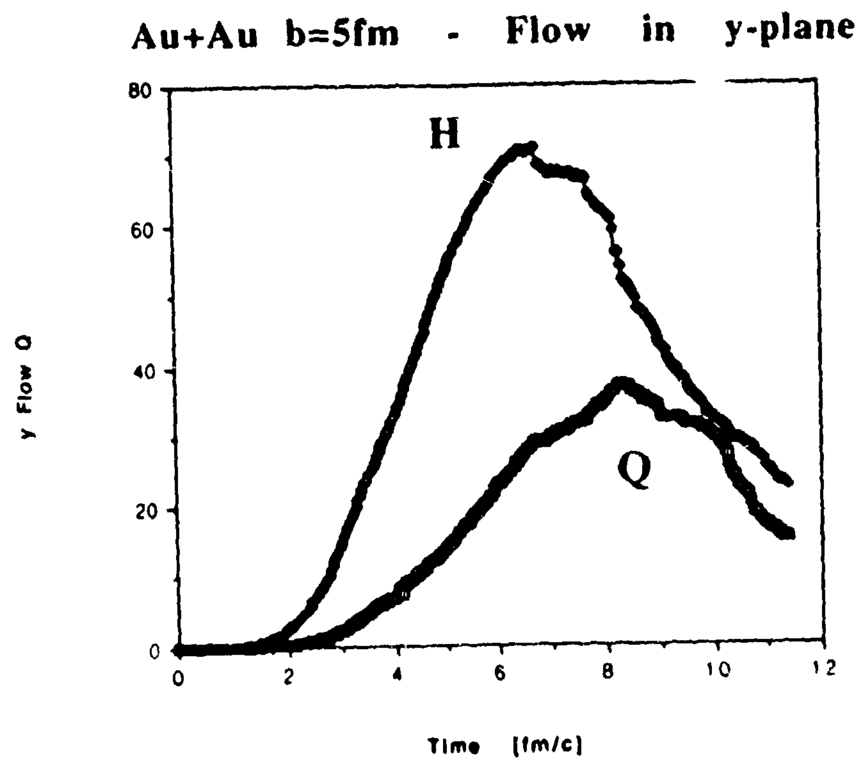

Figure 2: Average flow in the y-direction [arbitrary units], as function of time in an Au+Au collision at 11.6 A GeV and b=5 fm, for QGP (Q) and Hadronic (H) EOS.

The rapidity distribution is again not strongly dependent on the EOS, although it indicates strong stopping. A double hump structure representative of the slowed down spectators is more apparent for the hadronic FOS.

The transverse flow analysis, $< p_x/A >$, is also a sensitive indicator of the EOS. $< p_x/A >$ is much smaller than $< p_t/A > \approx 1$GeV/c. For the Au+Au, 11.6 A GeV reaction at b=5 fm $< p_x/A > \approx 500$, (350)MeV/c for Hadronic, (QGP) EOS at the target or projectile rapidity (Fig. 3). In the QGSM the transverse flow is smaller, but still a large and observable effect (Fig. 3).

The space time pattern of a collision is different in the two models, and in the fluid dynamical model it strongly depends on the EOS. Due to the higher compression with QGP the area of the most dense region is almost half of this area with the hadronic EOS. On the other hand the lifetime of the dense matter is about 60-80% longer.

In the QGSM we studied the space time pattern of the region occupied by strings or non formed particles. This region [illegible] than the [illegible] in fluid dynamics and it decays in a different pattern. While in fluid dynamics the dense

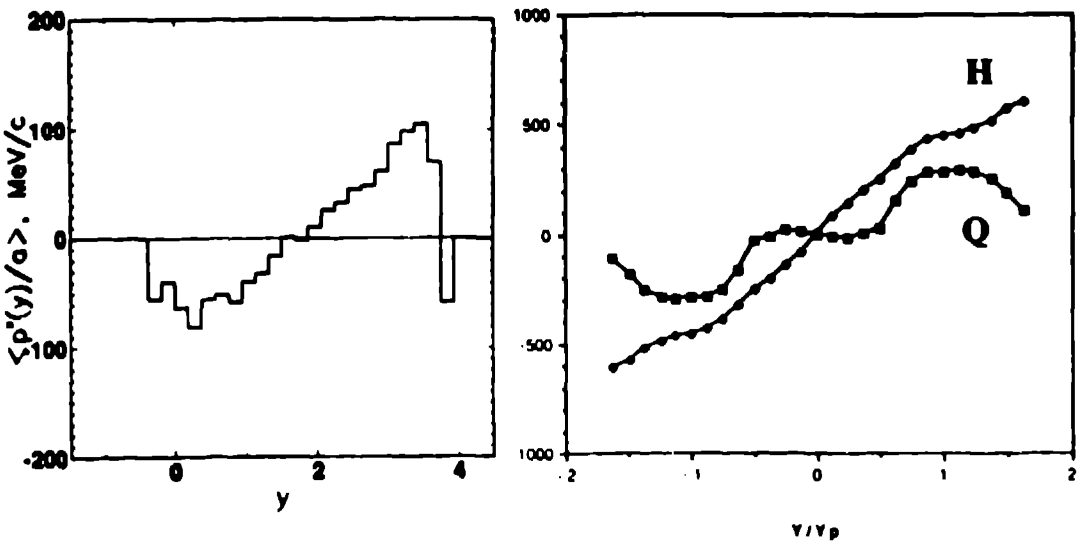

Figure 3: Average transverse flow, $< p_x/A >$, in an Au+Au collision at 11.6 A.GeV. **A:** In the QGSM at b=3fm, plotted versus Y (left). **B:** In the Fluid Dynamical model for b=5fm, for QGP (Q) and Hadronic (H) EOS, plotted versus Y/Y_p (right).

region disappears along t=const. or τ=const. surfaces, in QGSM the string-region decays at its outside surface surviving quite long in the middle, ca. 10 fm/c.

In conclusion we suggest to study the collective flow behaviour in the Au+Au reactions at AGS. According to our theoretical predictions these collective effects are well measurable at AGS using the same or similar methods that were used at BEVALAC. Both the transverse flow, $< p_x/A >$, but particularly the squeeze-out effect are particularly sensitive to the precursors of the transition to the QGP. If both the bounce off and squeeze-out are identified the signal of the pre- phase transition softening of the EOS is indicated by the smaller squeeze-out versus bounce-off ratio than measured at the BEVALAC.

A significant amount of QGP is not expected to be formed at this energy, but the signs of the phase transition due to the effects of the mixed phase is observable.

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